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WOOD DISTILLATION.

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[Note.—The Forest Service has received many inquiries about the commercial distillation of hardwoods and softwoods and the quantity of the products obtained. It has been impossible to answer these inquiries by letter as fully as desired, and the growing need of a popular publication which would briefly state a few facts on wood distillation has been strongly felt. For this reason this circular has been compiled. It is not intended to be technical in nature or to contain the results of original investigations, but rather to furnish a few facts concerning the wood distillation industry as it now stands in this country. Circulars of a more technical character and dealing with concrete problems in wood distillation will follow.]

INTRODUCTION.

There are two distinct processes for obtaining valuable products from wood by distillation—destructive distillation and steam distillation. In the destructive process the wood fiber is broken down and new compounds are formed, but in the steam process this is not properly the case. In both processes the volatile compounds of the wood are vaporized.

In destructive distillation heat is applied below the wood-containing vessel, which has a comparatively small pipe as its only outlet. The heat vaporizes the volatile compounds, such as water and turpentine, and breaks down the nonvolatile compounds, such as cellulose and the wood gums; it forms a number of new compounds, usually of a simpler chemical nature, and these in turn are vaporized with the water and turpentine, leaving a residue of charcoal. The decomposition of the wood in this process is exceedingly complicated and is not yet fully understood.

In steam distillation, which is much simpler, the wood is chipped and placed in a closed receptacle into which steam is blown from a boiler, and the volatile compounds which are not chemically united with the rest are vaporized and carried out of the retort with the steam. Though in practice the wood is often so much overheated that the wood fiber is slightly decomposed, and though it is quite possible to carry the overheating so far that the process becomes one

of destructive distillation, it is nevertheless true that "steam distillation," as the term is technically used, signifies the separation of volatile products from wood with, at most, but little decomposition of the wood fiber.

With both these processes the vaporized compounds after leaving the retort pass through water-cooled tubes, where they are condensed into the crude liquors which after refining yield marketable products.

Different woods give different marketable products after distillation. Thus, the hardwoods—beech, birch, and maple—yield acetate of lime, wood alcohol, and charcoal, and longleaf pine yields turpentine, tar, pine oils, and charcoal. This difference in the products is due to the fact that pine woods are resinous, while hardwoods are nonresinous. From the point of view of products, therefore, it is necessary to distinguish between the kinds of wood used, as well as between the distillation processes.

DESTRUCTIVE DISTILLATION OF HARDWOOD.

Hardwood distillation has been an established industry in the United States for a number of years. The products already mentioned are wood alcohol, charcoal, and acetate of lime, each of which has important uses. The plants are located in the northern part of the United States, where, except for the Appalachian hardwood belt, the hardwoods are most common.

The woods used are largely beech, birch, and maple, with the last preferred. The wood is cut into cordwood lengths and allowed to season for a year. According to the best information, the amount of the products obtained from green wood and from ordinary dry wood is not different, cord for cord, but the higher water content of green wood dilutes the distillate and necessitates more fuel for the carbonization. Excessive seasoning will doubtless reduce the yield of valuable constituents. Body wood is better than slab wood. Very small wood, such as thin edgings, carbonizes so rapidly that it must be mixed with larger pieces. The problem of the destructive distillation of sawdust has not yet been satisfactorily solved.

APPARATUS.

Wood is heated or carbonized in three forms of apparatus: (*a*) In brick kilns, (*b*) in retorts, (*c*) in ovens.

The charring of wood is a process as old as civilization. In the early days the wood was charred under sod in the old charcoal kiln, which has been a familiar sight over a good part of the world. The modern charcoal kiln is so made that valuable vapors are condensed from the smoke, which in the old-fashioned kiln escaped into the air and were wasted. Kilns are now mainly used to produce charcoal for blast furnaces for pig iron. They are made of brick, with a circular base, and divided approximately into two semicircular sections. They hold each about 50 cords, and are charged and discharged by hand. The vapors are carried off into condensers, where the condensable ones are liquefied.

The name "retort" is given to a small form of cylindrical vessel holding about three-fourths of a cord. The retorts are set horizontally in brickwork, in pairs, each pair forming a "battery," and heated from beneath. They are filled and discharged from a single

door in front, which can be tightly fastened. The top of the battery is often tiled and serves as a drying floor for acetate of lime. The condensers are of copper, and are cooled by water. A "run," from charging to recharging, takes twenty-four hours.

The invention of the "oven" form of carbonizing vessel marked a distinct forward step in wood distillation. Oven kilns are made large enough to hold from two to four cars, which are run in on tracks, each loaded with about 2 cords of wood. They are usually fired separately, and the vapors pass over into the condensers either at the side or at the end. In other respects they resemble the "retorts."

PRODUCTS.

Four crude products are obtained from each of these forms of carbonizing vessels: (1) Charcoal, which remains in the vessel; (2) a noncondensible gas, which is carried off by suitable pipes; (3) an aqueous liquor known as "pyroligneous acid;" and (4) wood tar, which is condensed with the pyroligneous acid.

The charcoal is cooled differently in the case of each distilling vessel, though in all cases it is cooled for forty-eight hours. With kilns, it is allowed to cool before being removed; with the retorts, it is shoveled into drums or cans and sealed from the air; and with the ovens, the loaded cars are run out and closed in large coolers, which are similar in form to the ovens.

The gas from the kilns is piped back into the kiln furnaces, where it serves to carbonize the wood. The gas from retorts and ovens is burned under the boilers or under the retorts.

The pyroligneous acid and the tar run off together from the condensers into vats, where the tar settles. The pyroligneous acid is reddish brown in color and has a strong, characteristic, burnt-wood odor. The tar, when in thin layers, is dark brown in color, and has a bad odor. These two liquid products are refined by processes which in general are the same for each of the three forms of carbonizing apparatus. The processes differ somewhat, however, at the different plants.

Dissolved in the tar are some of the valuable compounds of the pyroligneous acid, while dissolved in the pyroligneous acid are some tarry bodies. Both liquids are distilled in order to concentrate the valuable substances, which are chiefly acetic acid and methyl, or wood, alcohol. The concentrated liquid containing the acetic acid and methyl alcohol is neutralized with lime and distilled from a "limelee" still, giving (1) a residue which upon evaporation yields gray acetate of lime, and (2) a distillate which upon refining yields the various grades of wood alcohol.

Some plants obtain a crude, brown, evil-smelling wood alcohol, of 82 per cent strength, which is sent to a refinery for further treatment; others obtain a 95 to 99 per cent product without color or unpleasant odor. Wood alcohol is ill-smelling only when impure as a result of incomplete refining.

Oven and retort plants which produce alcohol no purer than 82 per cent secure about the following average yields from wood distillation per cord of wood:

Charcoal	45 to 52 bushels.
Gray acetate of lime	180 to 225 pounds.
Wood alcohol, 82 per cent	8 to 10 gallons.

The lack of chemical supervision at the works makes statements of yield a little confusing, since wood alcohol and acetate of lime are variable in quality and the number of gallons and pounds may therefore actually represent products of quite different composition.

Kiln plants obtain about the following yield per cord of wood:

Charcoal	45 to 52 bushels.
Acetate of lime	90 to 150 pounds.
Wood alcohol, 82 per cent	4 to 6 gallons.

USE OF PRODUCTS.

These compounds have a variety of uses, which may be briefly mentioned. Charcoal is used in blast furnaces for the production of pig iron, in copper and sugar refineries, in the production of gunpowder, for fuel, etc. Wood alcohol is sold under a variety of trade names, such as "columbian spirit" and "colonial spirit." It is most widely used as a solvent in the production of shellacs and varnishes. It is also used in hat making, in perfumery, in the coal-tar dye industry, in manufacture of formaldehyde, and for mixing with grain alcohol to produce "denatured" or "industrial" alcohol. The acetate of lime is a gray, finely crystalline body, which is used in the manufacture of wood vinegar, acetic acid, many commercial acetates, acetic ether, acetone, and other products. (From the acetone may be produced iodoform and chloroform.)

A number of receipts for the preparation of denatured alcohol have been recently authorized by Congress and established by the Commissioner of Internal Revenue, so that denatured alcohol, with its due admixture of wood alcohol, is now a market article. The wood distillation plants now in existence in the United States are able to produce probably 30,000,000 gallons of wood alcohol annually.

Denatured alcohol is now a competitor of wood alcohol. At present the producers and refiners of wood alcohol are in suspense as regards the extent of the consumption of the product for denaturing purposes.

STEAM DISTILLATION OF HARDWOOD.

Several species of hardwood are distilled by steam in order to obtain valuable essential oils. Sweet birch, for example, yields "oil of wintergreen," an oil used in medicinal preparations. No thorough study has yet been made of this division of the subject, but it is known that a small industry is supported.

DESTRUCTIVE DISTILLATION OF YELLOW PINE.

The destructive distillation of yellow pine is carried on in the Southern States, where the distillation plants are so widely scattered that a statement of the location by States would mean but little.

The wood generally used is that of longleaf pine, from which turpentine and rosin are mainly obtained. At some plants, however, longleaf pine, shortleaf pine, Cuban pine, and others are indiscriminately used, but for the best results longleaf and Cuban pines are selected. The most valuable material is wood rich in resinous contents, or "fat," in which lightwood and stumps rank first, wood immediately under the "box faces" next, and slabs and other mill refuse last. Pine sawdust is not used for destructive distillation.

APPARATUS.

Iron or steel retorts are used, varying in capacity from 1 to 4 cords. They are either vertical or horizontal. The vertical retorts have their long axis upright, and are set singly in brickwork with suitable flues, usually with the openings for charging and discharging at the top and bottom. The firebox below is at one side, so that the heat goes around the outside of the retort itself. Few of these retorts re now in use.

The horizontal retorts are similar to those used in hardwood distillation. Though they differ as to form, all are cylindrical steel vessels set in batteries in brickwork and are charged and discharged through doors at one or both ends. The gases escape through pipes to copper condensers. The firebox is sometimes constructed to fire two retorts at a time, though usually but one.

PRODUCTS.

Though there are a number of methods which differ somewhat in results, the five products usually obtained are: (1) Charcoal; (2) a noncondensible gas; (3) light oils, which are often taken in two fractions, one of which is a crude turpentine; (4) tar, and (5) pyroligneous acid. At some plants the light oil vapor, which volatilizes easily, is led off into condensers with the gas and pyroligneous acid, while the tar, which is heavier, is drawn off at the bottom; at others, the entire volatile product is driven off through a pipe at the top and, after passing through the condenser, is separated into the crude turpentine and tar fractions.

There is no more uniformity in heating methods than in the form of the retorts. The run is thirty-six or forty-eight hours, or longer.

Charcoal which is to be sold is cooled in the retort, and that which is to be used for fuel is drawn hot and sprayed with water to prevent fire. The gas is allowed to run to waste or is burned under the retorts and boilers.

The pyroligneous acid from hardwoods contains the most valuable products, but that from pine, which has a strong odor and a reddish-brown color, is of such different composition that very little is done with it. The yield from a cord of pine wood is, according to the most widely accepted figures, not more than 3 gallons of 82 per cent wood alcohol and about 70 pounds of brown acetate of lime. The extraction of wood alcohol from pine wood is not at present on a commercial basis, and at the majority of plants the pyroligneous acid runs to waste.

The crude turpentine is a dark red oil with the bad odor associated with products of destructive distillation. After proper fractional distillation, it yields for market a nearly colorless turpentine, which has a distinctive odor.

The tar is sometimes refined far enough to produce a good quality of retort tar and to yield oils which, with the heavy distillates from the crude turpentine, make disinfectants, wood creosote, and a number of market articles.

The refining processes, which are largely secret, are not the same at all plants, while the products sold are far from uniform.

Since few plants operate under the same conditions, and since a number of products may be obtained from the tar and crude turpentine, it is difficult to estimate the amount of products obtained from yellow pine. Moreover, the wood itself varies widely in resinous content. Heavy, rich "lightwood" contains the largest quantities of turpentine and other oils, whereas other kinds of "lightwood" may yield but little. Sapwood yields the least. The following table shows as nearly as practicable the ordinary yields per cord of wood obtained in practice by the destructive process:

Refined turpentine	7 to 12 gallons.
Total oils, including tar	50 to 75 gallons.
Tar	40 to 60 gallons.
Charcoal	25 to 35 bushels.

USES OF PRODUCTS.

The turpentine is used as a second grade, inferior to gum turpentine. There are no recognized grades of destructively distilled turpentine, and the composition of the turpentine from different plants is not uniform. Formerly it was poorly refined; it is now made practically colorless. In the refining, certain heavy oils are obtained, which, when combined with similar heavy oils from the tar, are made into "pine oils," used as disinfectants, paint dryers, wood preservatives, etc. One of the uses for the tar is cable coating. The uses of the acetate of lime, in this case "brown acetate," have already been mentioned. The charcoal is burned at the plant or sold for fuel. The pyroligneous acid in its crude form is occasionally sold, although most of it goes to waste.

Several causes have led to many failures among plants of this kind. One of these was bad management. Men engaged in the business, without training or a knowledge of the market, expected an immediate demand for the products. Another cause was the use of inferior retorts, which in many cases were made of thin steel and so were quickly burned out. A third was lack of perseverance when difficulties arose.

STEAM DISTILLATION OF YELLOW PINE.

The plants which distil wood by the steam method are located in the yellow pine belt. In general, the wood is the same as that used for the destructive distillation of yellow pine, but is separated into classes. Steam plants use the richest wood that can be secured, since turpentine is the only valuable product, although the wood after extraction is used for fuel. The wood is divided into three classes: (1) The rich "lightwood," of which several grades are used; (2) stumps, which are also rich in turpentine; and (3) sawmill waste, which includes sawdust, butt cuts, and slabs. All wood must be "hogged" into chips before it is placed in the retorts.

APPARATUS.

Both vertical and horizontal retorts are successfully used. But the wood is treated by two different methods, one using superheated steam under low pressure and the other saturated steam under higher pressure.

With superheated steam a vertical retort is used, and the steam, before entering the retort, passes through a superheater, which raises its temperature high enough to readily volatilize the turpentine. From the condensers the distillates run into a separator.

For saturated steam several sorts of retorts are used, and the steam enters them directly from the boiler. There are a number of patented devices, the most important differences in which have to do with methods of charging and discharging. The fundamental idea, however, is to maintain a sufficient pressure of steam, throughout the run, to facilitate rapid extractions. A separator is used, as with superheated steam.

PRODUCTS.

The products of both processes are crude turpentine and water, in a separator tank, and chips left in the retort. The turpentine, which is lighter than water, floats on the surface and is easily drawn off, ready for refining. The chips, after drying a short time in the air, are suitable for fuel.

In order to obtain a market grade of turpentine, the crude product should be refined by distillation with steam in a copper still. As it comes from the retort its color is slightly yellow.

There is the same variety in methods used as in other kinds of wood distillation, and consequently the same lack of uniformity in the products. Much remains to be learned as to the best method of refining turpentine so as regularly to secure the best grades.

The amount of turpentine obtained from steam distillation varies widely. The wood itself varies greatly in richness. A conservative average per cord is given in the following table (the difference between stumps and "lightwood" is slight enough to be disregarded):

Lightwood:	
Refined turpentine	10 to 15 gallons.
Heavy oils	1 to 3 gallons.
Sawdust:	
Refined turpentine	2 to 4 gallons.
Heavy oils	½ gallon.

The refined turpentine is of reasonably uniform quality, is nearly colorless, has an agreeable odor, and has a fair market at a price somewhat below the market price for gum spirits of turpentine.

COMPARISON OF METHODS.

Comparing the steam methods with the destructive methods, although there is room for difference of opinion, it would seem that the steam distillation is open to the wider development. The successful destructive distillation plants are those which are run by men who have remained in the business long enough to establish their processes and methods and the markets for their products. Turpentine, the leading product, is probably produced less expensively by the steam method, and the steam apparatus necessary to handle a given quantity of wood per day, say 50 cords, is easier to operate.

There have been fewer failures in steam distillation than in destructive distillation, perhaps because it is of more recent development, and

because those promoting the enterprises have been able to profit by the mistakes of their predecessors. Yet many operators have failed, mainly because they had not familiarized themselves with the fundamental principles controlling the successful construction and operation of a plant.

The figures on pages 6 and 7 are not intended to compare yields by destructive and steam distillation from the same grade of wood, but simply the yields obtained by the two methods under actual conditions, where, in point of fact, very different grades of wood are used.

There is but scanty published information on the properties of the turpentines produced by these two processes in America, or on their actual value in the paint and varnish business. Up to the present these turpentines are merely competitors of "gum spirits."

Approved:

JAMES WILSON,
Secretary of Agriculture.

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